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ABSTRACT

This study involved approximately 1,000 girls and 300 boys from the seventh, eighth, and ninth grades of five Michigan junior high schools. The girls were randomly divided into five groups. Group A received live presentations by women engineers; Group B participated in four engineering projects; Group C received only printed materials; Group D received no special instruction, but their parents received printed materials, as did the parents of students in Groups A, B, and C; and Group E was the control group. A test instrument designed to measure awareness and attitudes toward engineering was administered before and after the study to all girl participants, controls, parents and faculty. The analysis portion of the study had not been completed at the time of this report. (MLH)

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A STUDY OF THE AWARENESS AND ATTITUDES OF JUNIOR HIGH GIRLS TOWARD ENGINEERING AND EXPERIMENTS WITH METHODS OF INCREASING THEIR AWARENESS AND INTEREST IN ENGINEERING

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A Study of the Awareness and Attitudes of Junior High Girls toward Engineering and Experiments with Methods of Increasing their Awareness and Interest in Engineering

by

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INTRODUCTION

Background

During the early seventies, enrollments in Engineering colleges had reached a level[(1)]* that was too low to assure a supply of qualified graduates to fill all the positions available at that time. Moreover, Labor Department projections[(2)] indicate that the discrepancy between supply and demand for engineers will not only continue but perhaps even increase during the rest of the decade especially if there is substantial recovery from the recession. Women currently represent slightly over 1% of the engineering work force. However, these women have proved that they can do engineering work successfully and derive the same satisfactions from it that men do.[(3)] Approximately as many girls are qualified to enter engineering colleges as boys. In the extreme case, the supply of engineering graduates would be doubled if women could be persuaded to enter the profession in the same proportions as men. This would supply much needed engineering talent, a need that when compared with supply exceeds the needs of more abstractly trained science graduates[(4)]. These additional women with engineering degrees would also enlarge the pool from which middle and top level management personnel could be selected.

*Numbers in parentheses refer to sources identified by number in the list of References at the end of the paper.

Object of Study

The project reported in this paper was a study of the attitudes and awareness of eighth grade girls toward engineering, toward careers for women, and toward their own futures. The effectiveness of four different ways of informing them about engineering and motivating some to enter engineering and physical science who otherwise would not do so was compared by means of before and after responses to a survey instrument developed as a part of the project.

The program was intended to reach these students at an age that would be early enough to enable them to schedule appropriate mathematics and science courses in high school and to help motivate them to put forth serious effort in those courses. Taking mathematics and science courses in high school will allow them to confirm their interest and obtain the formal background they need to keep engineering and physical science as viable career choices upon graduation from high school.

As a part of the project, cost studies were made to determine which treatments in the Engineering Awareness phase are economically feasible for implementation on a long range national level. The project carried out by the authors was one of 22 sponsored by the National Science Foundation during the 1974-75 fiscal year in an attempt to determine what factors were responsible for the low proportion of women in science related careers.

Scope

The study involved about 1000 girls and 300 boys from five different junior high schools in Michigan, mainly eighth graders but with some seventh and ninth

graders for comparison purposes. The experiments were carried out in three of the schools intended to be broadly representative of the State and of the Country. Two schools were chosen from a large metropolitan area and one of the larger schools from the sparsely populated Upper Peninsula. Of the two city schools, one was from the inner city and one from the suburbs. While it would be desirable theoretically to study very small rural schools, the enrollment necessary to make statistical comparisons would not be available in smaller schools.

The eighth grade level was selected because in most schools, at the end of the eighth grade, students must choose among courses and curricula that begin to separate students who consider high school terminal from students who are college bound. The college bound begin to separate between those who wish to pursue liberal arts programs and those who wish to pursue a scientific education. Decisions are made beginning at the ninth grade about the amount and level of mathematics, science, and English. A change in track can still be made at the tenth grade level but transfer from a "noncollege" curriculum to one that prepares the student for college work in engineering or physical science is very difficult. Girls who can be inspired as eighth graders might not only make curricular choices that would lead toward Engineering but also might benefit from increased motivation in those courses because they have clearer career goals in mind.

Surveys

The test instrument, designed to measure awareness and attitudes toward engineering, was administered in the fall of 1974 to some 700 (essentially all) eighth grade girls in the three main schools, their parents, their teachers, and their counselors. Between five and six hundred students at two other junior high schools were also included in the survey as controls and to help obtain certain other information.

The surveys were intended to answer the following questions:

What level of awareness do eighth grade girls, their parents, teachers, and counselors have about

a. the job of an engineer
b. placement opportunities for an engineer, and
c. opportunities for women in engineering?

What attitudes do eighth grade girls, their parents, teachers, and counselors exhibit toward

a. engineering, and
b. women in engineering?

What effect will contacts with women engineers, information about engineering and experiences with engineering-related activities have on the awareness of and attitude toward engineering of eighth grade girls from various types of schools?

Which method(s) of introducing information about engineering is (are) most cost-effective in improving the awareness and attitude of eighth grade girls toward engineering?

What problems and cost would be encountered in implementing on a national scale those methods found to be successful in this project?

PROCEDURE

Preliminary Phase

During the summer preceding the conduct of the study in the junior high schools, the attitude survey instrument was developed with the assistance of a consultant, Dr. Wayne W. Welch of the Educational Research and Development Office of the University of Minnesota. The preliminary version of the instrument was tested on three different groups of girls. The first group consisted of twelve eighth grade girls from a local school who went through the forms individually in the presence of their school counselor who served as a consultant for the project. The girls were asked to identify words with which they were not familiar and statements they did not understand. This student panel was selected to include a broad range of reading abilities and sophistication of career awareness. They also evaluated much of the printed matter that was being considered for use in the project.

The survey instrument was next tested with twenty 13 and 14 year old girls who were enrolled in the Michigan Tech Summer Youth Program. They came from a variety of backgrounds and interests but were assumed to be reasonably representative of eighth grade girls.

The third group to respond to the preliminary version of the survey instrument was a set of 104 high school girls, mostly 11th graders, on the last day of a five day intensive workshop entitled Women in Engineering. This group had been selected for their high academic achievement and demonstrated interests in science and mathematics. Their workshop experience had provided

maximum contact with practicing women engineers and others from whom they got authoritative information about opportunities in engineering.

The survey responses of the two groups of eighth grade girls who were unsophisticated in their knowledge and exposure to engineering were compared with the responses of the older girls who had considerable knowledge and above average interest in Engineering. Survey questions which did not discriminate between the two groups were eliminated or rewritten in developing the final version of the questionnaire.

Planning Conference

Success of the project was dependent on effective cooperation of nine individuals: the director, the contact persons at the three junior high schools, the engineering practitioner, the engineering professor (coauthor of this paper, who was also responsible for development of the survey instrument, analysis and interpretation of the experimental data, and was involved in many other important aspects of the project), and the three students who were to assist in the treatments of Group A and B. An all day planning conference was held September 30 at which all nine got acquainted, decided on the calendar of events, clarified who was to do what, and made various other decisions about the conduct of the project.

One major factor whose implications were not previously understood emerged from these discussions. The racial identity of those who would administer treatments to the girls was judged to be critical at the Inner City and Suburban schools but of little or no significance at the Upper Peninsula

school. This factor and scheduling difficulties encountered later led to the expansion of the number of engineering students to help with the project to six.

Fall Survey

A carefully designed awareness and attitude survey was made during the fall of 1974 of all the eighth grade girls at each of the three schools selected, their parents, their teachers, and their counselors. The survey included a variety of questions about engineering and the students' future careers. The questions about engineering sought to determine their awareness of and attitudes toward engineering careers, job placement, advancement opportunities, etc. The questions of the students' future careers sought to assess their attitudes toward and realistic knowledge of their future lives as adult women. Questions concerned career aspirations, career-family conflicts, traditional vs. non-traditional occupations for women, etc. The awareness and attitude surveys of parents, teachers, and counselors asked essentially the same questions as those asked the girls but were appropriately worded for their respective roles.

The survey instrument consisted of four parts: Engineering Awareness, Career Attitudes, Semantic Differential, and Biographical. Only the first two parts were suitable for use with parents and teachers and not all schools were willing to request biographical information from their students. A copy of the survey instrument is available upon request.

TREATMENTS

The girls at each school were divided into five groups of equal size and random qualifications for the experimental aspects of the study. In two schools

this was on an alphabetical basis and in one it was on the basis of homeroom assignment. Students who dropped out or changed schools during the year were omitted from the final data.

Group A Treatment

The treatment of Group A at each school started in November with an audio-visual presentation. At the Inner City school which had 100% black enrollment, the film[5] "A Piece of the Action" was used. At the other two schools, which had only white students, an adaptation of the 3 projector-3 screen slide-tape show[6] "Creating a Better World through Engineering" was used. Several slides in the original set were replaced by others chosen to portray a better balance of women and minority engineers in addition to white males.

The main treatment for Group A consisted of live presentations by women engineers. In February, a woman engineering student visited each school, told about her experiences as a student and how she perceived engineering as a career for women. Two different students were involved in these presentations, a black student at the Inner City school and a white student at the other two. The first was a junior metallurgical engineer and the second, a senior mechanical engineer. Both had had summer experience in industry. Each took along some items for the girls to see and handle. Their presentations were necessarily different but had similar objectives. Both emphasized what was involved in preparing for an engineering career.

The third presentation to Group A was in March by a woman practitioner of engineering from industry. A white chemical engineer with three years

experience in the paper industry was scheduled to make presentations at all three schools but a misunderstanding resulted from a mix-up of schedules at the Inner City school and a minority student (Spanish surname) with co-op experience as a mechanical engineer in industry was called on to make the presentation extemporaneously. These presentations emphasized what engineering was like on the job.

The final presentation to Group A girls was in April by a woman electrical engineering professor, the coauthor of this paper. She discussed the ways in which a career in engineering can be combined with marriage and a family, noting the options available to young women. She also described work in computer engineering and demonstrated an electronic dice game designed and constructed by one of her sophomore students.

Group A girls also received printed matter at various intervals, usually about a week apart. These items included most of the ECPD guidance material, NSPE's piece, 2 Engineering Manpower Commission bulletins, some SWE material, etc.

Group B Treatment

The Group B girls participated in four engineering projects chosen from Civil, Mechanical, Metallurgical, and Electrical Engineering. Each project took one class period--about 55 minutes. The first three projects were administered by undergraduate engineering students, all women except for one. The last project was handled by the woman engineering professor. The goal of the projects was to give the girls a feel for engineering through hands-on experience with simple engineering problems and equipment.

Civil Engineering. The Civil Engineering project was in the realm of environmental engineering, the determination of the amount of dissolved oxygen in water as a measure of water pollution. The project required the girls to mix two chemicals with water samples and then titrate the resulting mixture with a third chemical to measure the amount of dissolved oxygen. After watching the leader demonstrate the procedure, teams of girls carried out the test on samples of either polluted water or tap water.

Mechanical Engineering. The Mechanical Engineering project involved an electric resistance strain gage. The leader explained some of the theory of strain gage operation and gave examples of its use. Then girls, working in groups of two or three, used known weights to calibrate a strain gage mounted on a cantilever beam. They plotted the calibration data and thus learned about handling such engineering drawing instruments as a French curve. After they completed the calibration curve, they used it to determine the weight of a variety of simple objects such as coins, pencils, etc.

Metallurgical Engineering. The Metallurgical Engineering project gave the Group B girls "hands-on" experience with an assortment of metallurgical items. The leader demonstrated and explained the applications of each object before giving it to the girls to explore. The experiences included magnetic separating iron ore from rock, observing the behavior of a nickle-titanium alloy "with a memory" under the application of heat, investigating thermal expansion of a bimetallic disc, etc. In addition, the girls viewed and handled specimens of various metallurgical materials and examined pictures taken

through an electron microscope. The leader also discussed important current problems that metallurgical engineers are studying with an emphasis on environmental problems.

Electrical Engineering. The Electrical Engineering project was concerned with simple logic circuits. The leader explained AND and OR gates and demonstrated the operation of a simple logic board with switches, AND and OR integrated circuits, and a LED light. The girls, working in groups of two or three, then constructed and tested several simple logic circuits of varying degrees of complexity.

Each administrator of a Group B project had a practice session with a group of 10 or 12 girls in one of the local schools. This helped in predicting how much could be accomplished in one class period, in anticipating questions girls might ask, and in providing a measure of confidence that everything would work out satisfactorily. One student was not satisfied after one rehearsal and arranged for a second practice with a different group of students. That rehearsal and the actual "performance" went superbly.

The girls in Group B all received the same printed matter on the same schedule as used for Group A.

Problems

A variety of problems were encountered in administration of the treatments and more different individuals were involved then originally planned, especially with Group B. The contact person at the Inner City school strongly advised minimizing the number of whites who would visit their students and suggested

scheduling the audio-visual and the minority persons first. At the Suburban school where the bussing issue had recently created ill feelings, the contact person advised against using any minority resource person. Since the project was concerned with engineering, not social justice, every effort was made to comply with the advice of the school officials.

Some scheduling problems were also encountered. In particular, one snowstrom could have been scheduled at a time which would have been less disruptive! A combination of complications resulted in six different engineering students being involved instead of three as intended.

Problems were also encountered in dealing with junior high girls of Group B, and to a lesser extent, Group A. Some of these problems stemmed from difficulty in scheduling the girls to report to the desired room at the desired time. The contact person at each school usually sent a mimeographed list to all teachers about one week in advance of all girls who would be missing from any class for the project. Some teachers refused to release girls from their classes despite the week's notice. In addition, control procedures at the school usually required that each girl be issued a hall pass so that she could leave her regularly scheduled class to attend the project session. Sometimes passes were not issued for each girl, or passes were misdirected. In addition, the junior high schools were often short of space and were accommodating other special projects. On at least two occasions this resulted in the scheduling of another group into the room assigned to the project group and hasty compromise arrangements had to be made. Another problem encountered toward the end of the

project was that some girls refused to attend the scheduled session either because of a competing event, e.g., the movie Kung Fu in their English class, or because they were not interested in the project. All these problems were in addition to the anticipated problem of normal absences with the consequence that not all girls in a group got the same experience.

Other Treatment Groups

Group C received the same printed materials on engineering as Groups A and B but had no special programs, projects, or contact with the resource persons.

Group D had no programs, no projects, no discussions, and no printed information. However, their parents did receive the same information as parents of Groups A, B, and C (see the section entitled "parents").

Group E at each school was a control group. Neither the girls in Group E nor their parents received any information as a part of the project. They did, however, complete both the initial and final awareness and attitude surveys.

It was not possible to insulate Group E from the girls in the other groups in a project extending over eight months. They were in regular social contact and in various classes together. The controls, therefore, were expected to have received some information and have been influenced to some extent by their peers in other experimental groups. This influence or contamination of controls was expected to be observed as changes in some responses to the awareness and attitude surveys.

To provide a check on this eventuality, additional control Groups E' in two other schools were surveyed at the same times in the fall and spring without any informational program being provided to the students, their parents, teachers, or counselors as a part of this project. Comparison of initial and final survey responses of this group was expected to show whatever changes would result from information ordinarily available to junior high students at school, through the public media, and from normal maturation processes.

Three additional effects were also explored in these Group E' schools: the differences in information and attitudes toward engineering of boys and girls and of seventh and eighth graders, and the influence of the pretest on what they learned from ordinary sources. The following postulates were tested:

1. eighth graders would be more knowledgeable about careers and engineering than seventh graders.
2. boys would be more open to engineering than girls.
3. taking the pretest would make students more alert to information about engineering that they would encounter from normal sources during the year and therefore exhibit more change than those not pretested.

Parents

Parents of all girls in all five groups at the three primary participating schools were asked to respond by mail to the attitude surveys at the beginning and the end of the project. During the course of the project, parents of the girls in test groups A, B, C, and D received at home through the mail essentially the same printed information on engineering that the girls in groups A, B, and C received at school. Parents of girls in the control groups E and E' received no information about engineering at any time from project sources.

Only one parent of each girl was asked to respond to the survey, the choice of respondent being left to the family. However, the same parent was requested to respond to both the initial and final surveys.

Teachers and Counselors

All faculty members (teachers and counselors of both sexes) involved with 8th grade girls at the three primary participating schools were asked to participate in the attitude surveys at the beginning and end of the project and received sets of printed information selected for them.

Not all parents or teachers were persuaded to respond to either the fall or spring survey but literature was not withheld due to lack of response. The wishes of parents at the suburban school who declined to give permission for their daughters to participate in the project were respected.

Table I shows in tabular form the treatments planned for each group.

Table 1. Summary of Treatments

	AV	Lect.	Disc.	Q & A	Lab	Printed information		
						girls	parents	teachers & counselors
A	X	X	X	X		X	X	X
B			X	X	X	X	X	X
C						X	X	X
D							X	X
E								X
E'								

Spring Survey

Late in April or early in May a second awareness and attitude survey was administered to all of the girl participants, controls, parents, and faculty to assess the changes that take place between fall and spring. The same instrument was used for the post test as for the pretest.

ANALYSIS OF RESULTS AND CONCLUSIONS

The results of both fall and spring attitude surveys are to be processed using SPSS. Initial and final attitudes are to be compared. Hypothesis of the efficacy of the four experimental programs vs the null hypothesis are to be checked with changes in awareness and attitude as criteria. Changes which result from the four different treatment groups will be compared with the cost incurred with each group to draw conclusions about the cost effectiveness of each.

The analysis portion of the project had not been completed when this paper was written. This is partly due to an unrealistic schedule which assumed immediate response from parents, allowed no time for delays at the junior high schools, and provided too little time for carrying out the steps required to get the data ready for the computer. One other factor provided the clincher. Irreversible biological processes culminated in the arrival of a bouncing baby boy born to the member of the project team who was responsible for the data analysis in the midst of the period when data was to be analyzed. As soon as the detailed results are available, presumably by fall, 1975 they will be available to any interested person upon request.

Observations

Most students in each of the schools did show considerable interest in the "hands on" projects and cooperated in what they were asked to do. Most of the Group A presentations were also well received but the greater formality and lesser degree of activity made it harder to get them enthused. Students seemed to enjoy both audio-visual presentations but the movie, by virtue of its less

serious approach and the fact it was a movie, seemed to have greater appeal than the slide-tape show.

The printed matter was, to a large extent, over the heads of eighth graders except as resource material for a paper that might have been assigned. There were two noteworthy exceptions: The Quincy comic book (General Electric) and the E. C. P. D. booklet "Engineering: Creating a Better World" which made liberal use of cartoons. Two of the more expensive booklets, WOMENGINEER developed by students at the University of Illinois, and distributed through E. C. P. D. and the GE slick paper multicolored booklet, "What its like to be an Engineer" attracted some attention. Some of the other pieces were excellent for well motivated adults seeking information.

The cooperation of the parents and teachers is indicated to a considerable degree by the numbers in Table 2. The initial approach to the parents was a letter over the signature of the contact person or principal of the respective junior highs on school stationery. When responses did not come back at the rate hoped for, a follow-up letter was sent by the project director on University letterhead. The follow-up letter for the fall survey was accompanied by a second copy of the questionnaire in case the first had been lost. In the spring survey the cover letter with the survey form and the reminder letter to slow respondents were both signed by the director.

Table 2. Survey Responses

	Parents Number	Fall No. /%	Spring No. /%	Faculty Number	Fall No. /%	Spring No. /%
Inner City	285	80/28%	24/8%	44	21/48%	14/32%
Suburban	224	151/67%	82/37%	37	30/81%	
Upper Peninsula	200	131/66%	72/36%	40	38/95%	41/85%

The response rate for the Inner City school was less than half that for the others, presumably because of less emphasis on written material and less contact with professionals in those families.

Teacher response to the surveys was short of unbounded enthusiasm. Some seemed to be disinclined to bother and uncertainty about what might be the "right" answers to some of the questions may have posed somewhat of a threat to some. However, persistence on the part of the contact persons pried loose responses from a higher proportion of the teachers then could be achieved with parents.

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6. University of Nebraska slide-tape presentation, "Creating a Better World Through Engineering," 13 minutes, 1973.